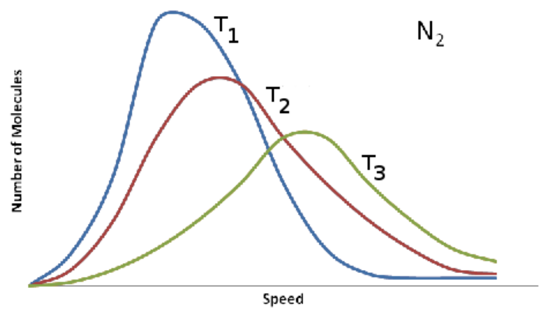
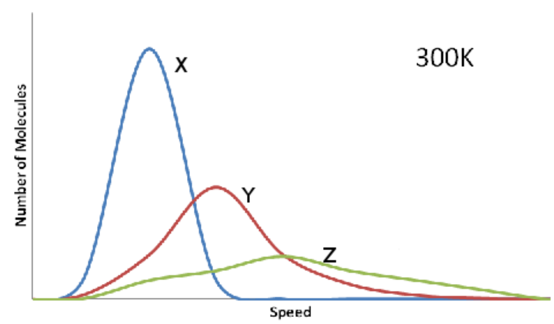
1 Morning class Week 2 Day 3: Working exam problems

1. **The Maxwell-Boltzmann distribution**

   (a) The three temperatures in the graph below correspond to 100 K, 300 K and 700 K. Which one is which?



   (b) The graph below is for three different molecules, He, Cl_2 and N_2. Which compound goes with which curve?



2. **At the dentist's office**

   (a) A 50 mg sample of dental cement, composed of a single chemical compound, contains 16.58 mg oxygen, 8.02 mg phosphorous, and 25.40 mg zinc. The molecular mass of this compound is between 250 and 400 g/mol. What is the molecular formula of this compound?

   (b) What is the chemical subject of the problem? What techniques are used in solving the problem? What new insights did the problem and the problem solution give you?

3. **Heating a solid mixture**

   (a) Upon heating, 120.34 g of a mixed $AlCl_3$ and $CaCl_2$ sample is reduced into 33.456 g of a metallic alloy which contains no chlorine. No metal atom leaves the sample. What was the molar ratio of the $AlCl_3$ to the total number of moles of compound in the initial chloride containing sample?

(b) What is the chemical subject of the problem? What techniques are used in solving the problem? What new insights did the problem and the problem solution give you?

4. **Ideal gases and chemical reactions**

(a) **A chemical reaction with ideal gases** There are two types of energy. Potential energy is the energy of repulsion and attraction. Kinetic energy is the energy of movement. Ideal gases only have kinetic energy.
Monoatomic ideal gases follow the kinetic energy law, $E = \frac{3}{2}nRT$. By contrast, linear-shaped ideal gases, follow a different kinetic energy law: $E = \frac{5}{2}nRT$. Note all the molecules considered in this problem are linear. Consider the following unbalanced reaction:

$$CO(g) + O_2(g) \longrightarrow CO_2(g)$$

At STP in a sealed flask, every mole of CO_2 formed by this reaction produces 100 kJ of energy. Initially the flask is at STP and contains 1 mole of CO and half a mole of O_2. After reaction all the CO is consumed by this reaction. Assuming no energy is transferred between the walls of the flask and the gas, what is the final temperature of the flask?

(b) What is the chemical subject of the problem? What techniques are used in solving the problem? What new insights did the problem and the problem solution give you?

5. **Zut alors!**

(a) The French scientist La Cheville-Tordue is studying real gases. She has determined the a and b parameters for carbon dioxide (CO_2), ammonia (NH_3), carbon disulfide (CS_2), dodecane ($C_{20}H_{42}$), and neon (Ne) for the van der Waals equation:

$$(p + a\frac{n^2}{V^2})(V - nb) = nRT.$$

At 1 atm, ammonia and carbon dioxide are both gases, ammonia having the higher boiling point. At 1 atm, carbon disulfide and dodecane boil at respectively 46 and 216^{o}C

Compound	a (L^2atm/mol^2)	b (L/mol)
X	3.610	0.0427
Y	4.250	——
Z	11.10	0.0726
W	——	0.3758
Q	0.214	0.0171

Unfortunately she has forgotten to record which line of data goes with which compound (note for **X**, La Cheville-Tordue has also forgotten to determine b). Please deduce which of the five compounds goes with which line of data.

(b) What is the chemical subject of the problem? What techniques are used in solving the problem? What new insights did the problem and the problem solution give you?